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Before the
Federal Communications Commission
Washington, D.C. 20554

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OCT 25 1996

In the Matter of)

Revision of the Commission's Rules)
to Ensure Compatibility with)
Enhanced 911 Emergency Calling Systems)

FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

CC Docket No. 94-102

REPLY COMMENTS OF KSI INC. AND MULOC INC.

KSI Inc. and MULOC Inc., the developer and owner respectively of location-determination technology (collectively "KSI"), hereby submit these Reply Comments pursuant to Section 1.415(c) of the Commission's Rules in the above-referenced proceeding.¹

Founded in 1986, KSI began and continues as a business of experts in the design, development, integration, evaluation, and sale of detection, localization, and tracking systems. Since its inception, scientists, and engineers at KSI have earned a reputation as developers of, supervisors for, and highly respected experts in the implementation of localization systems for the analyses of electromagnetic (RF), acoustic (sound), and seismic (vibration) source signals/events. In addition to the development of its pioneer Angle Of Arrival (AOA) wireless localization system,

¹ In the Matter of Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems, CC Docket No. 94-102, RM-8143, FCC 96-264, released July 26, 1996 (Report and Order and Further Notice of Proposed Rulemaking) ("Report and Order" and "FNPRM").

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KSI has designed and implemented very capable Time Difference Of Arrival (TDOA) systems for suitable applications. KSI has also provided insight into implementation issues concerning multiple Global Positioning System (GPS)-based systems. KSI has consistently advocated the licensing of its existing pioneer intellectual property, and any subsequently issued intellectual property, on fair terms to ensure full public benefit.²

In the Report and Order in this proceeding, the Commission set a standard for location accuracy of 125 meters root mean square ("rms") that must be achieved in five years. As was the case with petitions for reconsideration of that Report and Order, no commenter in this phase of the proceedings has offered any supportable justification for relaxing that standard. KSI believes that five years is ample time for the implementation of the necessary facilities in all CMRS domains. The FNPRM questions whether a more ambitious standard can be achieved in that same time period -- location accuracy of 40 feet in latitude, longitude and altitude in 90 percent of all cases. While KSI has demonstrated that location accuracy within 125 meters in latitude and longitude is possible 90 percent of the time, KSI does not advocate that the FNPRM's proposed 40-foot objectives are achievable in five years. Whereas a combination of capabilities, as discussed in KSI's FNPRM

² In its Comments at 9, Omnipoint Communications, Inc. expresses concern that owners of intellectual property rights may be forced to disclose their technology and grant licenses to other equipment manufacturers. KSI represented to the October 1994 Joint Expert Meeting that it would be willing to license its technology to others on commercially fair and reasonable terms.

comments, may support an accuracy "goal" of 40 feet under some conditions, the costs are likely to be a major factor limiting consideration. As set forth below, KSI does support the adoption of requirements for maximum time latency and for the updating of location information reported to the public service answering points ("PSAPs").

Other developers of location system technologies have corroborated and supported the types of location requirements, capabilities, and facilities that KSI has been urging in its Comments, Reply Comments, ex parte filings, and Additional Comments previously submitted in these proceedings. In particular, Associated RT, Inc. ("ART") has discussed various issues involved in the feasibility and specification of various location accuracy standards and in the utility of latency and update requirements for the location information that is to be provided to the PSAPs. KSI agrees with many of the points discussed in ART's comments, but wishes to correct several misunderstandings that may be conveyed by other points in ART's comments.

Based on ART's discussion of the fundamental location accuracies that can be expected from the processing of received communications signals, one could mistakenly construe that the limitations attendant to the Time Difference Of Arrival (TDOA) techniques used in ART's location system implementations are equally characteristic of KSI's Direction Finding Localization

System (DFLS), which uses Angle Of Arrival (AOA) techniques.³ For TDOA measurements, ART describes the Cramer-Rao bounds, which establish the theoretical lower (i.e., best) limits for accuracy, in terms of processing parameters such as the received signal-to-noise power ratios and the time-bandwidth product. The optimal TDOA accuracy is also proportional to the inverse of the signal's rms "spanned bandwidth," which is approximated by half of the bandwidth. While noting that "similar forms ... apply for ... (AOA) based location systems," ART did not clarify that the TDOA and AOA Cramer-Rao forms are essentially identical in the processing-parameter terms but are significantly different in other terms. For the band-limited signals of interest in RF communications, the theoretical accuracies achievable for AOA measurements are proportional to the receiving antenna's wavelength-to-aperture ratio, rather than to the inverse of the bandwidth. These differences result in AOA measurements that are equally accurate for a RF communications signal of any bandwidth, whereas TDOA measurement accuracies are significantly degraded for signals such as those of the AMPS analog voice channels which have limited bandwidth.

For each particular localization technology, the optimally expected location accuracies derive directly from the associated measurement accuracy dependencies discussed above. For a comparison of typical location accuracies that derive from the AOA

³ See Comments of Associated RT, Inc. at 19-20.

and TDOA relations, we can assume a simple (inexpensive) AOA-antenna configuration with a one-wavelength aperture and can apply the antenna-site spacings of a suburban environment (three miles) to assess the Geometric Dilution Of Precision (GDOP) applied to the AOA measurements. Even assuming negligible GDOP for TDOA measurements, the location accuracy for the AOA system would typically be over five times better (i.e., smaller) than that of the TDOA system using the control channel parameters (20 kHz bandwidth) set forth by ART.⁴ For the AMPS voice channel, the estimated AOA location accuracies are 25 to 100 times better than those of a TDOA system due to bandwidth-limitation effects.⁵ The AOA-based localization accuracies are not constrained by the bandwidth-related limitations of the TDOA-based accuracies, such as those that occur with AMPS analog voice-channel transmissions or with the bandwidth restrictions of narrowband AMPS configurations.

Because the AOA-based localization accuracies are not dependent upon the availability of any form of signal modulation (which produces any required signal bandwidth), the same basic AOA signal processing for localization can be applied to either control or voice transmissions. In previous submissions to these proceedings, KSI has provided actual, field-trial, example results, showing not only the localization of fixed (stationary) transmitters on both control and analog voice channels, but also

⁴ Id. at 21.

⁵ Id. at 18, 22 and 24.

the tracking of transmitters on the voice channels while in motion (including through handoffs). All of these results were obtained with the application of a single form of signal AOA processing. The presence or absence of signal modulation or bandwidth does not affect the AOA results. Of course, since a typical cellular control-channel transmission only lasts approximately 100 milliseconds, the control-channel processing can only locate the transmitter at the instant of transmission. On the other hand, as long as a voice-channel connection is maintained with a mobile caller, the transmitter can be continuously and repeatedly located with AOA measurements on the current voice channel.

Both initial location based on control-channel processing and updated information based on voice-channel processing can clearly facilitate better, more timely, PSAP response. As AT&T Wireless Services, Inc. stated, "... moving a cellular phone merely a few centimeters can cause a variance in the strongest signal ...⁶" and, thus, the use of only the Phase I cell identity for routing can potentially adversely affect the choice of the PSAP to which the call is initially routed. Lucent Technologies has noted that "(l)ocation information should be available during call setup for accurate routing. If detailed information is unavailable immediately, then coarse location could be used for routing."⁷ That is, the "coarse" information should be augmented by the updated

⁶ Comments of AT&T Wireless Services, Inc. at 5.

⁷ Comments of Lucent Technologies, Inc. at 5.

"detailed" information to facilitate rapid emergency response.

Based on the foregoing, KSI urges the Commission to heed the PSAP-community requests that the PSAP facility be able to obtain updated locations of a 911 caller as a call is in progress. The October 1994 Joint Expert Meeting identified the ability for the PSAP to request individual or periodic updates to caller location information as a basic requirement, with a priority above even the capability for initial call routing to the appropriate PSAP.⁸ Mobile callers who need help, such as victims of stalkers, must be tracked. A Good Samaritan caller, who reports a need for help but who is in motion and is no longer near the location of need, may describe the location as "behind" her or him. The direction of motion obtained by tracking the call enables the PSAP operator to quickly determine the appropriate location for response from the caller's location and motion. Similarly, updated locations enable the PSAP operator to resolve apparent conflicts between the initial location estimate and information communicated by voice, and to refine or improve location estimates by averaging or integrating successive locations even when the caller is stationary. Because it is capable of processing either analog or digital voice channels, AOA techniques can supply updated locations to the PSAP without the need for exploiting modifications in phones, modulation techniques, or the basic signal processing techniques.

Since AOA-based localization techniques are not dependent upon

⁸ "Wireless Support of 9-1-1 and Enhanced 9-1-1 Emergency Services," Report of the Joint Expert Meeting (released Nov. 2, 1994).

the modulation characteristics or content of any particular air interface, they can be simply applied with standard receivers designed for the normal reception of signals in each air interface. As described in KSI's prior submissions, the AOA measurement process at each antenna site applies the standard receivers appropriate for any air interface to exploit the inter-element phase relations among the signals captured with the directionally sensitive, multi-element antenna. The received phase relations for any particular received signal are dependent on the directional angle of arrival of the signal, but are independent of the modulation techniques or information content in the communications, and can be determined equally accurately even when the signal is pure carrier, devoid of any modulation. Thus, AOA-based localization techniques are equally applicable to all air interfaces, and the localization standards imposed by the Commission in the Report and Order do not inherently limit the CMRS carriers' interface choices.

For the foregoing reasons, KSI respectfully urges the Commission to refrain from imposing a location accuracy standard that requires 90 percent accuracy within 40 feet in latitude, longitude and altitude and to adopt a maximum time latency period and update requirement consistent with that set forth in the FNPRM.

Respectfully submitted,

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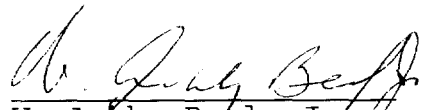
I, W. Ashby Beal, Jr., do hereby certify that a copy of the foregoing Reply Comments of Ksi Inc. and MULOC Inc. were served via U.S. Mail, first class postage pre-paid, on the following:

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